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The demographics of decarbonizing transport: The influence of gender, education, occupation, age, and household size on electric mobility preferences in the Nordic region

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ABSTRACT

Many researchers, policymakers and other stakeholders have explored and supported efforts to transition towards more sustainable forms of low-carbon mobility. Often, discussion will flow from a narrow view of consumer perceptions surrounding passenger vehicles—presuming that users act in rationalist, instrumental, and predictable patterns. In this paper, we hold that a better understanding of the social and demographic perceptions of electric vehicles (compared to other forms of mobility, including conventional cars) is needed. We provide a comparative and mixed methods assessment of the demographics of electric mobility and stated preferences for electric vehicles, drawing primarily on a survey distributed to more than 5000 respondents across Denmark, Finland, Iceland, Norway and Sweden. We examine how gender influences preferences; how experience in the form of education and occupation shape preferences; and how aging and household size impact preferences. In doing so we hope to reveal the more complex social dynamics behind how potential adopters consider and calculate various aspects of conventional mobility, electric mobility, and vehicle-to-grid (V2G) systems. In particular, our results suggest that predominantly men, those with higher levels of education in full time employment, especially with occupations in civil society or academia, and below middle age (30–45), are the most likely to buy them. However, our analysis also reveals other market segments where electric vehicles may take root, e.g. among higher income females and retirees/pensioners. Moreover, few respondents were orientated towards V2G, independent of their demographic attributes. Our empirical results can inform ongoing discussions about energy and transport policy, the drivers of environmental change, and deliberations over sustainability transitions.

1. Introduction

The continuing diffusion of privately owned, gasoline-powered vehicles used primarily by single occupants is a major source of several pressing social problems inclusive of deteriorating air quality, aggravated climate change, congestion, and negative alterations to urban form and function. Many policymakers and other stakeholders have explored and supported efforts to transition towards more sustainable forms of mobility, such as more efficient vehicles, vehicles powered by low-carbon fuels, and improved transit and urban density. To date, however, few of these efforts have substantially improved the sustainability of global transportation systems.

Often, academic and policy discussions of mobility or low-carbon transitions have shortcomings. Firstly, they advance a narrow view of consumer perceptions surrounding passenger vehicles—as if the only

meaning behind conventional use concerns its basic functions (e.g. a means to get somewhere) and the private financial costs involved in doing so (Chen and Kockelman, 2016). From this limited viewpoint, an alternative mobility paradigm needs only to replicate these functions in a way that is either similar or better than the status quo in order to be successful; other alternatives are marginalized if not entirely obscured (Bergman et al., 2017). Secondly, most techno-economic assessments of innovation or decarbonization have a limited representation of the actors involved (mostly firms and consumers interacting via markets, which are shaped by exogenous policymakers) and overly simplistic models of their decision-making (rational, optimizing) (Stern et al., 2016). Likewise, academic accounts of transitions within the field of automobility studies largely focus on “manufacturers and regulators, strategies and policies” but neglect “consideration of consumers, early adopters, and related ideas” (Wells and Nieuwenhuis, 2012). Thirdly,

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many popular conceptual frameworks, such as Rogers “Diffusion of Innovations” approach, represent transitions as tame processes with smooth diffusion curves (Geels, 2014), when in reality they are more abrupt, discontinuous, and unpredictable (Geels et al., 2018). Fourthly, the policy mechanisms literature tends to be gender or demographic neutral (presuming that a single mechanism such as a carbon tax will work across all markets or market segments) and that incentives can be reduced to mere financial numbers (such as \$2500 or \$20,000 per vehicle) (Hardman et al., 2017). Similarly, some literature argues that diffusion patterns for EVs are politically determined by electric vehicle or transport policy at singular national, state or city levels (Stokes et al., 2018; Heidrich et al., 2017).

In this paper, we argue that such dominant perspectives are ill equipped to deal with the required “revolution” needed to transition to electric mobility. Instead, we hold that any rapid and comprehensive transition to electric mobility will require a combination of technological, regulatory, institutional, economic, cultural and behavioral changes that together transform the sociotechnical systems that provide energy or mobility services (Geels et al., 2017). A central part of this process is better understanding the social perceptions of electric vehicles (compared to other forms of mobility, including conventional cars). This is especially the case given that full battery electric vehicles (EVs) represent not only a consumer choice problem about what car to purchase, but a behavioral adjustment problem given functional characteristics such as limited range and availability of charging. Bockarjova and Steg make the analogy that EV adoption is therefore more similar to health-related challenges such as quitting tobacco smoking or promoting exercise, which require older behavioral patterns to be “broken” and new behaviors “established” (Bockarjova and Steg, 2014). In this process, Bergantino and Catalano (2016: 342) write that “age, gender, working condition and the number of young children have proved to be significant explanatory factors of respondents’ psychological profiles.”

But how? In this paper, we provide a comparative and quantitative assessment of the demographics of electric mobility and its influence on stated interest in electric vehicles, including the potential for such vehicles to be configured with vehicle-to-grid capabilities (V2G) where they can store energy and offer services to the grid (Sovacool et al., 2017). Based primarily on a survey distributed to more than 5000 respondents across five countries, and supplemented with a comprehensive literature review and bivariate statistical analysis, we examine how perceptions and attitudes towards electric vehicles and V2G differ by gender, education, occupation, age, and household size. In doing so we hope to reveal the more complex social dynamics behind how potential adopters in Denmark, Finland, Iceland, Norway, and Sweden say they consider and calculate various aspects of mobility. We also seek to inform ongoing discussions about energy and transport policy, the drivers of environmental change, and deliberations over sustainability transitions.

While we did not use our data to invent a particular theory or model, in line with other empirical studies (Marquart-Pyatt et al., 2014; Unsworth and Fielding, 2014; Knox-Hayes et al., 2013), our findings can be used to validate existing approaches or generate new ones. We would also underscore the novelty of our approach in terms of emphasizing V2G (extremely rare in the literature), including a comparatively larger sample size (enhancing the validity of our findings), analyzing a sample that included hundreds of actual EV owners and adopters (also a rarity), and looking at a nexus of demographic attributes (gender, education, employment, occupation, age, and household size) rather than only one or few. Ultimately, our research can be framed more as confirmatory (testing and validating earlier hypotheses in the literature) than exploratory (generating entirely new hypotheses) (Sovacool et al., 2018).

Lending support to our approach, Arranz (2017) conducted a meta-analysis of 44 sociotechnical transitions across electricity, heat, and transport. Although she did not study demographics directly, she noted

that “societal factors” such as lifestyle or ideals played a significant role in many of the transport transitions analyzed. Perceptions of pollution, notions of hygiene, attitudes towards inconvenience, and changes in tastes all affected preferences for safety or lifestyle, or buttressed beliefs about progress, quality, or national prestige. She posited that results from previous transport transitions in particular suggest that social aspects become “very important” once a sector is more open to competition, arguably the case concerning electric mobility in the Nordic region. As such, we maintain that better comprehending the demographics of electric mobility becomes paramount to better analyzing the social elements of both historical transition processes as well as future transition pathways.

2. Research methods and limitations

To collect data on the demographics of electric mobility, our primary method was a structured questionnaire (an online survey) consisting of three parts with 44 total questions (including a choice experiment, which we do not report here). The first part asked about the vehicle background and the existing mobility patterns of respondents, namely how often they drive or use other forms of transport, how far, how much they are willing to pay for a new car, etc. The second part asked respondents what they valued most (or least) when they considered future purchases and forms of mobility, such as acceleration, size, safety, etc. as well as some questions specifically about electric vehicles (such as charging availability, range, battery life, and so on), asking them to rate these features according to a five point Likert (1932) type scale ranging from very unimportant to very important. The final part of the survey asked respondents for basic demographic information such as age, gender, education, and occupation as well as more sensitive questions about income, political affiliation, and environmental values (among others). A complete copy of the survey is offered in the Supplementary Online Material (SOM).

Distribution of the survey was online and anonymous, with a research design intended to minimize dishonesty and promote candor. For instance, psychological studies of survey design have found that the more impersonal the conditions, the more honest people will be. For eliciting truthful answers, internet surveys are better than phone surveys, which are better than in-person surveys, as “people will admit more if they are alone than if others are in the room with them” (Stephens-Davidowitz, 2017: 2). Our survey was completed by a mix of 4322 random respondents (facilitated through a survey hosting firm) and 745 non-random respondents (facilitated through an online version where the authors invited the public to participate) shown in Table 1. This puts the total respondent number at 5,067, and this already excludes surveys that were incomplete (although we allowed for people to skip questions) or obviously answered falsely.

Admittedly, our research design has a number of limitations. First, we ended up combining the sample of randomized respondents with a purposeful sample to increase response rates from Iceland and in particular to include more adopters or previous owners of electric vehicles. Both of these are hard to reach groups that were underrepresented in the randomized sample. Indeed, in their review of the literature, Rezvani et al. (2015: 130) caution that a flaw many survey articles have

Table 1
Summary of survey distribution.

Country	Respondents (random)	Respondents (non-random)	Total
Denmark	953	185	1138
Finland	962	143	1105
Iceland	496	214	710
Norway	959	103	1062
Sweden	952	100	1052
Total	4322	745	5067

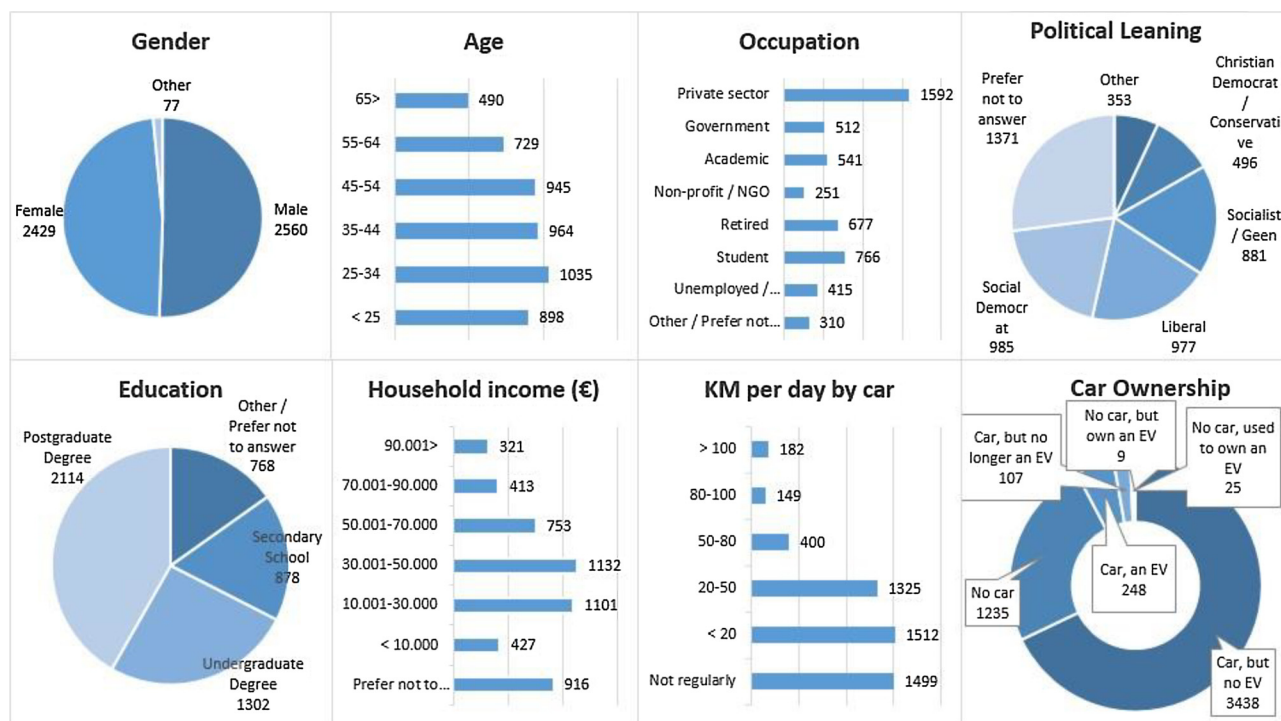


Fig. 1. Demographic characteristics of Nordic survey respondents.

is that they recruit “participants who have had no direct experience of EVs on which to base their responses” and are thus “psychologically distant from EVs,” limiting “the validity of inferences about adoption drawn from their responses.” Second, we treat stated preferences as stable and fixed, soliciting them at a single point in time, whereas in reality they are flexible, fluid, and co-constructed over time. Third, our approach may be prone to selection bias in that only those expressing a strong interest in the topic of electric mobility or V2G would potentially take the time to complete the survey. Nonetheless, as Fig. 1 indicates, our combined sample shows a fair distribution across gender, age, political orientation, and education. Simultaneously, the combined sample of respondents shows considerable variance for occupation (more private sector participants than others), income (most respondents in middle ranges of household income), kilometers travelled (most fewer than 50 km a day), and car ownership (most own at least one car).

The survey results were analyzed descriptively with the help of frequency analyses and single level statistical analyses. Granted, many studies use a more robust statistical approach, such as multivariate analysis, cluster analysis, or stated choice experiments, which go “beyond” demographics to identify the underlying constructs that explain part of the demographic associations, while controlling for others (Hackbarth and Madlener, 2013; Peters and Dütschke, 2014; Axsen et al., 2016; Hackbarth and Madlener, 2016; Morton et al., 2017). However, our aim was to use bivariate statistical tests in an explorative manner to find clear associations, influences, and variances between the demographic variables (e.g., gender, education, age) and the variables on car use, electric vehicle background and vehicle preferences. Rather than “back fit” these results around only the most interesting or significant findings, we instead present all data in both quantitative and qualitative (narrative) form.

We place this analysis against a backdrop of a comprehensive review of the academic literature published in the past ten years on the topic of electric vehicle diffusion. To help frame our hypotheses, and also better ground our results within the literature, we searched for studies published with the words “electric mobility,” “mobility,” “electric vehicle,” “carbon,” “travel” and “transport” in the titles,

abstract, and keywords of full length articles alongside the words “gender,” “women,” “men,” “identity,” “education,” “training,” “occupation,” “employment,” “age,” “elderly,” “aging,” “family,” “household size,” and “children.” Although not meant to be a systematic review, meaning that the results were not coded nor was formal content analysis conducted, we collected approximately 70 studies to examine, many of which are cited throughout the article. The sample of studies for our literature review were global in scope, and not limited to European or Nordic countries, with the general idea being to collect as much data as possible. However, it does mean that the summaries from this body of literature are not always directly applicable or transferable to our Nordic results—cultural influence (and other factors) can largely influence preferences and how they are driven by socio-demographics, but the findings from the literature are not adjusted or normalized accordingly.

3. Gender and electric mobility

3.1. Previous global literature

Over the past four decades, research has tended to affirm four different dimensions that make mobility (and electric mobility) gendered: via travel patterns and a “gender gap,” via the transmission of environmental or pro-sustainability values, via stated preferences for particular vehicle attributes or forms of mobility, and via gender roles and norms. As Solá (2016: 34) writes, “differences between women and men are found in several dimensions of mobility, and ... the magnitude of gender differences can shift between dimensions.” The first stream of research emphasizes gendered travel patterns or a “gap” in travel, with men more likely to travel further, with less destinations to travel, and women also traveling more frequently with children, and/or walking (European Commission, 2007; Kawgan-Kagan, 2015; Darshini and Advani, 2016; Zheng et al., 2016; Basaric et al., 2016). A second stream of research focuses instead on values or norms—implying that women hold more pro-environmental or pro-sustainability values that they can transmit or pass onto others, especially their children (O'Connor and Fisher, 1999; Denton, 2002; Viscusi and Zeckhauser, 2006; Kellstedt

et al., 2008). Some even advance a “Gender Socialization Theory” which suggests that “females tend to be socialized towards a feminine identity stressing attachment, empathy, and care, and males tend to be socialized towards a masculine identity stressing detachment, control, and mastery in many countries around the world” (McCright et al., 2016: 183). These general environmental values can spillover into a third stream of research showing how stated transport preferences can be gendered, such as women preferring smaller cars, or more fuel-efficient cars compared to men, or cycling more (Kronsell et al., 2016; Fan, 2017; Aldred et al., 2017). In Sweden, for example, more women value the environmental benefits of electric vehicles compared to men (Vassileva and Campillo, 2017). However, a survey in China found that gender was a limited explanatory factor in explaining preferences for new cars (Yang et al., 2017). A fourth and final stream of research discusses structural and hierarchical gender norms and roles. Research here takes note of the patriarchal nature of gender relations that demand that women subsume responsibility for the private sphere and the household in nurturing and caring roles, thereby limiting women’s freedom to assume positions of power or participation in the labor market, and reinforcing gender inequality in patterns of mobility (Solá, 2016; Fan, 2017; Scheiner and Holz-Rau, 2012).

3.2. Nordic findings

In our findings, gender is a constant and significant influence in relation to car use. As Table 2a and b summarize, women are less likely to own a car than males (70.4% of females versus 79.8% of males). With this comes a higher percentage of women who do not drive or drive shorter distances, but also that women have less driving experience with EVs (15.4% versus 28.7% of the men) or own one themselves (3% versus 6.9% of the men). Regarding vehicle preferences by women, there is weak but significant negative correlation between gender and interest in EVs and the importance they attach to the range that an EV can drive.

We see similar slightly lower rankings for the speed/acceleration of a car, for design and style, technical reliability, and battery lifetime of an EV. In turn, women seem inclined to attribute more importance to ease of operation, safety (78.1% of women vs 63.8% of men rank this as very important), cost attributes, the environmental impact of a car and the charging options around EVs. All of these correlations are fairly weak but significant and they point to an interesting discrepancy. While women seem to prefer the benefits of an EV (environmental impact, fuel economy, ease of operation) and deem the range slightly less of an issue than men, they still rank lower on their potential EV interest, and are less likely to have an EV or even to have tested one.

Clearly, some of the results reinforce typical men-women stereotypes, or the different approaches to cars. Simultaneously there are clear differences between men and women in the different countries and between men and women across the countries, but not always. For example, we have found a consistent 13–15% point difference in each of the countries of men and women having experience with an EV, even though the EV dispersion rate differs highly across the countries (Kester et al., 2018). Gender thus seems to determine or at least influence preferences independent of diverging national contexts.

4. Education and electric mobility

4.1. Previous global literature

Although far less extensive than the research on gender, the literature suggests that education can influence perceptions of sustainability, mobility, and/or electric mobility. Research has hypothesized that those with postgraduate and undergraduate education would place a higher value on protecting the environment, or developing more innovative (and lower carbon) sources of energy. This is because universities in particular are known to be institutions more liberal in

orientation, and therefore more supportive of socially optimal energy or transport technologies (Sovacool et al., 2012). For example, Baiocchi et al. (2010) examined education and total carbon emissions and conceded that they are positively correlated; however, higher education can reduce emissions once other factors are controlled for, lending support to the idea that enhanced knowledge of environmental problems increases with higher education and can result in lower carbon lifestyles. In the Netherlands, those with a degree from a higher educational institution have stronger preferences for spatial equity and equal access to mobility services as compared to less educated citizens (Mouter et al., 2017). In Sweden, research suggests that “a high level of education” is prominent among the early adopters of electric vehicles (Vassileva and Campillo, 2017). In Norway, the drivers of electric vehicles tend to have higher education than non-adopters and they report being “highly motivated” by environmental issues (alongside issues of cost) (McKinsey and Company, 2014).

However, Brand and Preston (2010) question the connection between education and lower-carbon mobility, and argue that those attending university or other forms of full time education have substantially greater emissions associated with transport than those who did not. Büchs et al. (2013: 118) similarly caution that education plays “an important role in higher emissions” and that “even after controlling for income, high education remains significant and positively related to emissions.” The coefficient between emissions and education is highest for transportation, where “households in which at least one person has been in full time education for 16 years or more have on average 17% higher emissions than the control group” (Büchs et al., 2013: 120).

4.2. Nordic findings

In our study, we do find that education is a significant influence in relation to preferences for cars, electric cars, and car preferences (although uncorrected for income, age and employment). As Table 3 indicates, regarding vehicle preferences, we observe a significant variance between levels of education and environmental awareness, by proxy of survey questions on the environmental consequences of car use. Interestingly, the variances become weaker when discussing EV preferences. While range and charging time are weakly related to higher levels of education, the importance for battery life and V2G seems shared across levels of education, while it is undergraduates that place more importance on public charging infrastructure.

5. Employment, occupation, and electric mobility

5.1. Previous global literature

Employment and occupation can also shape travel patterns (and preferences). A body of research suggests that unemployment can have strong effects on emissions, with emissions from home energy higher but those from transport and commuting lower. Multivariate studies that include employment status tend to note that unemployment is negatively associated with carbon emissions regardless of location (Gough et al., 2011), especially for home energy services such as heating (Meier and Rehman, 2010). In terms of transport more specifically, employment as a whole tends to increase commuting trips which can increase both transport related emissions and congestion (Bill et al., 2006). Büchs et al. (2013) find that however the unemployed have higher public transport emissions than households in employment. Kawgan-Kagan (2015) concludes that those with full-time employment are also more likely to use ridesharing. Abenoza et al. (2017) note that unemployment and parental leave see reductions in personal transport use, putting people into the category of “inactive travelers” for public transport. In their analysis of the United Kingdom, Morton et al. (2017) find that those most likely to be early adopters of electric vehicles are those with fulltime jobs.

In the domain of occupation, (admittedly older) research has

Table 2
Gendered differences in preferences for car ownership, electric mobility, and vehicle attributes.

a Top panel: quantitative presentation of data					
	Male	Female	Other /Prefer not to say	Subtotal	Chi-Square
Car Ownership					
No, I do not own a car	20.2%	29.6%		1269	$S^2 = (2, n = 5061) = 75.15, p < .001$
Yes, I do own a car	79.8%	70.4%		3793	
n	2558	2426	77		
Daily km travelled by car					
I don't regularly drive a car	23.5%	35.4%		1499	$S^2 = (10, n = 5066) = 208.08, p < .001$
I drive under 20 km a day	27.3%	32.8%		1512	
I drive 20–50 km a day	30.2%	22.3%		1325	
I drive 50–80 km a day	10.1%	5.6%		400	
I drive 80–100 km a day	4.0%	1.8%		149	
I drive over 100 km a day	4.8%	2.1%		182	
n	2560	2429	77		
EV driving experience					
Don't know or not sure	2.7%	4.2%		182	$S^2 = (4, n = 5064) = 151.11, p < .001$
No, I have not driven an EV before	68.6%	80.3%		3754	
Yes, I have driven an EV before	28.7%	15.4%		1129	
n	2558	2429	77		
EV Ownership					
No, never owned an electric vehicle	90.3%	94.9%		4678	$S^2 = (4, n = 5066) = 66.37, p < .00^a$
Yes, but no longer do	2.9%	2.1%		132	
Yes, I currently own one	6.9%	3.0%		257	
n	2560	2429	77		

b. Bottom panel: narrative presentation of data	
	Gender differences ^b
Car use^c	
Car Ownership	There is a significant association between gender and car ownership with 70.4% of women versus 79.8% of men owning a car ($r_s = -.108$). This extends to car ownership in the different countries, where a 10 % point gap exists between men and women who own a car in countries like Denmark and Sweden, and a 15 to 16 % point gap in Finland and Norway. However, in Iceland our sample shows the reverse: 7.8 % more women own a car than men.
KM per day	There is an association between gender and kilometers driven, with women driving fewer kilometers per day ($r_s = -.187$). For instance, 68.2 % of women say they drive less than 20 km a day versus 50.8% of men, and almost double the percentage of men drives more than 50 km a day (18.9% versus 9.5%). This association between gender and km a day is also valid within countries and for males and females across countries.
EV Experience	There is an association between gender and EV experience with 28.7% of men having tried an EV versus 15.4% of the women ($r_s = -.160$). Interestingly, a 13 to 15 % point difference between men and women is shared across the five Nordic countries, independent of the EV market (although more have tried EVs in Norway and Iceland).
EV Ownership	Men more often own or have owned an EV (6.9% vs 3.0% of women), although the difference is smaller for those who sold their EV. There is a similar association in Finland, Denmark ($p = .001$), and Sweden ($p = .001$), but less so for Iceland ($p = .054$) and Norway ($p = .046$). This is reflected in a relatively equally distributed discrepancy between men and women's EV ownership over the Nordics with a 3 to 5 % gap between men and women, with more men saying they own an EV in each of the countries.
EV Interest	Of those who never owned or do not currently own an EV, there is an association between gender and level of interest, with 60% of men stating they are <i>somewhat</i> or <i>very interested</i> , as opposed to 56% of women ($r_s = -.048$). This general trend partly extends to the countries where we find significant differences between the interest of men and women for Finland and to some extent for Sweden ($p = .012$), and there is a different distribution for both men and women individually across the countries. For instance, an almost equal percentage of Icelandic women and men are <i>very interested</i> (43% and 42% respectively), while in Finland an 11 % point gap exists, where more men are <i>very interested</i> making Finnish women least interested in EVs.
Expected costs next car	Women expect to buy less expensive cars than men as only 15% expect to buy a car with a value over €30.000 compared to 26.3% of the men. This association also returns within the countries ($p = < .003$).
Car preferences^d	
Design and engineering: Speed/acceleration, size/comfort, design/style, ease of operation	In general, all questions are ranked differently across gender ($p = < .003$), except for <i>size and comfort</i> , thus implying that men and women rank that more or less equally. However, men give more importance to <i>speed and acceleration</i> and <i>design and style</i> , while women rank <i>ease of operation</i> more important. That said, women from different countries answer significantly different on all these categories, while men do so only for <i>size and comfort</i> ($p = .007$) as Icelandic men rank this higher than the other countries. Interestingly, only in Norway do men and women rank these four attributes more or less equally.
Costs and Impacts: Technical reliability, safety, fuel economy/financial savings, price, environmental impact	In general, all questions are significantly different across gender. Men rank <i>technical reliability</i> higher, while women rank <i>safety</i> ($r = .154$ due to a 14.3 % point difference for very important), <i>fuel economy/financial savings</i> ($r = .110$), <i>price</i> ($r = .106$) and the question on <i>environmental impact</i> ($r = .113$ due to a 9.5 % point difference for women answering that they feel it <i>somewhat important</i> to <i>very important</i>). Across countries men rank these questions equally except for the importance of <i>fuel economy/financial savings</i> and <i>environmental impact</i> . Women on the other hand think differently on all of them except for <i>price</i> . This extends to the way men and women rank these questions differently within Denmark ($p = < .008$), Finland ($p = < .015$), Iceland ($p = < .035$), Norway ($p = < .003$) and Sweden ($p = < .002$), with the exception of men and women in Iceland who rank the importance of <i>technical reliability</i> similarly.
EV preferences: Range, Battery life, Public Charging, Charging time, V2G	In general, the questions are significantly different across gender, except for <i>battery life</i> and <i>EV charging time</i> where the distribution of answers is the same across categories of gender. Men find <i>EV range</i> ($r = -.128$) and <i>V2G capacity</i> more important while women have a higher mean rank for <i>public charging infrastructure</i> . Across the countries, males rate these questions differently ($p = < .04$) except for <i>EV charging time</i> and <i>V2G capacity</i> , while women disagree on all except <i>V2G capacity</i> . Looking within each of the countries, men and women rank <i>battery life</i> equally. But with the exception of Iceland they disagree on <i>range</i> in every country. Interestingly, in Sweden <i>range</i> is the only EV question that men and women rate differently.

Notes: ^aOver 20% of cells have a count of less than 5, ^bTests for male – female only, all tests $p < .001$, unless where indicated, ^cBased on Pearson Chi-Square test, ^dBased on independent-Samples Mann-Whitney U test.

Table 3
Educational differences in preferences for car ownership, electric mobility, and vehicle attributes.

a. Top panel: quantitative presentation of data					
	Other/Prefer not to answer	Secondary School	Undergraduate Degree	Postgraduate Degree	Chi-Square
Car Ownership					
No, I do not own a car	33.4%	28.8%	25.3%	19.8%	S2 (3, n = 5057) = 69.11, $p < .001$
Yes, I do own a car	66.6%	71.2%	74.7%	80.2%	
<i>n</i>	882	852	1275	2048	
Daily km travelled by car					
I don't regularly drive a car	37.0%	32.6%	30.2%	24.8%	S2 (15, n = 5062) = 62.75, $p < .001$
I drive under 20 km a day	28.2%	28.6%	30.1%	31.0%	
I drive 20–50 km a day	23.7%	25.8%	24.6%	28.3%	
I drive 50–80 km a day	6.6%	7.4%	9.0%	7.9%	
I drive 80–100 km a day	2.0%	2.8%	2.7%	3.5%	
I drive over 100 km a day	2.5%	2.8%	3.4%	4.5%	
<i>n</i>	882	853	1276	2051	
EV driving experience					
Don't know or not sure	7.1%	5.0%	2.5%	2.1%	S2 (6, n = 5060) = 113.41, $p < .001$
No, I have not driven an EV before	75.7%	78.5%	76.7%	70.0%	
Yes, I have driven an EV before	17.1%	16.4%	20.8%	27.8%	
<i>n</i>	882	853	1275	2050	
EV Ownership					
No, never owned an electric vehicle	96.0%	93.1%	91.3%	91.0%	S2 (6, n = 5062) = 24.68, $p < .001$
Yes, but no longer do	1.5%	2.2%	3.0%	3.0%	
Yes, I currently own one	2.5%	4.7%	5.7%	5.9%	
<i>n</i>	882	853	1276	2051	

b. Bottom panel: narrative presentation of data	
	Education ^a
Car use^b	
Car Ownership	Car ownership is associated with education ($r_s = .123$) with 80.2% of postgraduates owning a car versus 71.2% of secondary school graduates. This extends across all five Nordic countries.
Km per day	Daily car travel is associated with education ($r_s = .098$) with higher education weakly correlating to longer distances traveled (16% of the postgraduates drive over 50 km a day versus 13% of those with secondary education). Interestingly, this associations returns within Denmark ($p = .009$) and Finland ($p = .005$), but not so much to the other countries, in particular Norway.
EV experience	EV driving experience is associated with education ($r_s = .142$), with 16.4% of secondary school graduates having tried an EV versus 20.8% of undergraduates and 27.8% of the postgraduates. This association holds across all five countries.
EV Ownership	EV ownership is associated with education ($r_s = .058$), with 8.9% of postgraduates, 8.7% of undergraduates, and 6.9% of secondary school graduates owning or having owned an EV.
EV Interest (non-EV owners)	For those not owning an EV, their interest in electric vehicles is also associated with education ($r_s = .142$), with 50.1% of secondary school graduates <i>somewhat</i> or <i>very interested</i> , versus 58.4% of the undergraduates and 65.1% of the postgraduates. This significance extends to the countries ($p < .007$; with the exception of Iceland).
Expected purchase price of next car	The expected expenditure is associated with education ($r_s = .142$), with 24.5% of postgraduates expecting to pay more than €30,000 against 15.3% of secondary school graduates. Of course, there is a difference between the countries, which shows as education is associated with expected price within Denmark, Finland and Norway, but not in Iceland and Sweden.
Car preferences^c	
Design and engineering: Speed/acceleration, size/comfort, design/style, ease of operation	Of these four questions, only <i>ease of operation</i> shows significant differences between educational levels, with a mean rank that rises with educational level (median is four), although <i>speed and acceleration</i> and <i>size and comfort</i> ($p = .049$). In Denmark none of these show any significant differences, while in Sweden 3 out of 4 do (but $p = .013$, primarily due to a lower mean rank for the nondisclosure group).
Costs and Impacts: Technical reliability, safety, fuel economy/financial savings, price, environmental impact	Education shows significant differences for <i>technical reliability</i> , <i>purchase price</i> and <i>environmental impact</i> , whereby higher education implies a higher mean rank for <i>technical reliability</i> and <i>environmental impact</i> , while <i>price</i> is of more concern for lower educational levels and drops in median for the postgraduates. <i>Safety</i> and <i>fuel economy</i> are not significantly different across levels of education.
EV preferences: Range, Battery life, Public Charging, Charging time, V2G	There is no significant variance between education and the importance of <i>battery life</i> and <i>V2G capacity</i> , implying a shared level of concern across levels of education. The others do show variance ($p < .001$). The mean rank of <i>EV Range</i> increases with higher education while the importance of <i>public charging</i> is lowest for the nondisclosure category and then rises until the postgraduate group decreases its importance again. Lastly, charging time seems equally shared except for the nondisclosure category where the mean rank and median drops.

Notes: ^aAll tests $p < 0.001$, unless where indicated. ^bBased on Pearson Chi-Square test. ^cBased on Independent Sample Kruskal-Wallis test.

suggested that government and industry sector stakeholders will place comparatively greater emphasis on the importance of new, innovative systems compared to those in other sectors (Gottlieb and Matre, 1976). Sociological research has also identified a process of “institutional isomorphism” by which people come to share the same values and

mores of the organizations that they work for (DiMaggio and Powell, 1983). To extend this logic, in industry where the profit motive is strong, one would expect economic aspirations or commitment to conventional cars to trump environmental aspirations or preferences for electric vehicles. Dunlap and Olson (1984) have also found that,

compared to advocates of renewable energy, employees of oil and gas companies were more tolerant of the environmental insults associated with energy production and use, suggesting that the particular industry one is in can shape views about energy and mobility. More recently, Sovacool et al. (2012) postulated that those with industry occupations would deemphasize the importance of climate change mitigation and reducing environmental damages. A study in Sweden further notes that those in the conventional automobile industry in particular will tend to strongly prefer ordinary cars and resist electric vehicles for reasons of reduced after-sales revenue (Nykqvist and Nilsson, 2015).

5.2. Nordic findings

Our own results support the contention that occupation/employment is a meaningful influence in relation to car use, electric vehicle experience and car preferences. Table 4 shows how occupation is associated with car use, EV history and car preferences in different ways. Indeed, car ownership is predictably highest among those employed and especially the private sector. In many cases the private sector seems the obvious market for EVs with its high percentage of car ownership and kilometers driven a day, but looking closer we see a high percentage of academics showing interest in EVs, while the non-profit sector has the highest EV ownership share. Government officials and especially retirees are another market that should not be overlooked. The latter are a prime potential market (in line with an aging population – as discussed below), because even though they have relatively little EV experience, a low EV ownership rate, and seem less interested in EVs, they also have a high car ownership share, drive short distances, have relatively high budgets, demand less from the design of a car, and could benefit from the easy driving of an EV.

6. Aging and electric mobility

6.1. Previous global literature

A person's age can influence mobility patterns and preferences for EVs. Statistical studies have suggested that the relationship between age and transport emissions takes on an inverse u-shape with multiple turning points: both the young and old travel less than those in the middle, especially households with children (Büchs et al., 2013). Moreover, most of the developed world has an aging population that is expanding—in the United Kingdom, the age of the population over 65 is expected to grow from 16% in 2009 to 23% by 2034 (Emmerson et al., 2013); in the United States, 57 million people will be over the age of 65 by 2030 (Shaheen et al., 2016). This means “older adults are the fastest growing segment of the driving population” (Young et al., 2017: 460). Demographic growth, increased licensing rates, and increased motor vehicle use will combine to produce a marked increase in the number of older drivers on the road. We concur with O'Hern and Oxley (2015: 80) who write that “with a current ageing population throughout much of the developed world, there is an imminent need to understand the current transportation requirements of younger and older adults.” In that vein, we explore here how aging can affect transport preferences across youths and the elderly.

First, for youth and young adults, research has suggested that in Sweden students in particular (often below the age of 24) prefer mass transit, have a lower rate of holding driver's licenses, and a higher share of walking and cycling (with more active mobility lifestyles) (Abenzoza et al., 2017). In Finland, those aged 15–24 cycle more frequently (even in winter!), walk more frequently, are more likely to consider traffic congestion a serious problem, and more critical and skeptical of biofuel (Upham et al., 2015). Second, in terms of the elderly, this class of drivers often have more pronounced limitations on mobility. For a start, the elderly are at elevated risk for serious injury and fatal crashes, explained by their frailty or reduced tolerance to crash forces (Young et al., 2017). They often suffer from musculoskeletal conditions that

limit their personal mobility; or live with other chronic diseases such as cancer, diabetes or cardiovascular disease (Guell et al., 2016). As Emmerson et al. (2013: 175) argue, “There are no set rules with any decline in ageing but age related declines in strength, dexterity, vision, hearing, working memory and cognition can all influence the simple acts of turning the wheel or planning a journey.” The elderly get lost more frequently also, yet are less likely to use navigational tools or aiding technologies (Edwards et al., 2016).

For some of these reasons, older generations often prefer the personal, conventional automobile to other forms of mobility. In the United States, for instance, Newbold and Scott (2017: 59) write that “the personal automobile remains the preferred travel mode choice” for aging Baby Boomers and “driving and having access to a personal automobile remains an important aspect of quality of life, with research suggesting that aging populations have become more dependent on the automobile.” Another study in the rural United States concluded that “almost universally” those aged 65–74 drive themselves to most of their activities (Glasgow and Blakely, 2000). In California, 83% of senior adults surveyed reported driving short distances at least five times a month; and 100% of participants plan trips in advance (Shaheen et al., 2016). In Australia, older adults also strongly prefer private motorized transport, which accounts for about 70% of travel among that group (O'Hern and Oxley, 2015). Following this need and use, much literature on age and transport has focused on issues surrounding loss of a driving license (King et al., 2017). In the United Kingdom, research suggests that those over the age of 65 more strongly prefer park and ride facilities and buses (likely influenced by concessionary rates) (Clayton et al., 2014). Some research has indicated a specific preference among the elderly for electric mobility. In Austria, research has shown that early adopters of e-bikes are primarily persons aged 60 years or older who use their e-bike for leisure trips (Wolf and Seebauer, 2014).

6.2. Nordic findings

Our results indicate that age is clearly associated with car use, electric vehicle experience and car preferences most likely due to (but not controlled for) driver's license age limits, graduation and employment stages, and income stages. Table 5 reveals that age confirms earlier conclusions about occupation as we see a growing uptake of car ownership with age groups, although the most kilometers driven a day peaks around 40–60. At the same time, we see that EV interest is highest for the 25–34 age group and that this cohort also peaks in terms of EV experience, in line with a high importance attached to the environmental impact of cars. That said, price wise the over 65 age group in our sample (the retirees) was willing to pay more, often over € 30,000. Thus, the elderly may represent an attractive electric mobility market even though they have relatively little EV experience, a low EV ownership rate, and are less interested in EVs. Between these young and old age groups are the 45–64 cohorts. They literally fall between the extremes, with high car ownership percentages, higher daily driving distances, only moderate interest (relative to the younger and older categories) in EVs, scoring a bit lower on environmental impact while deeming EV range and public charging more important than the other age groups, and in general they seem to expect more reliability and stability from their cars.

7. Household size and electric mobility

7.1. Previous global literature

The final demographic dimension we explored was that of changes to household size. Previous literature suggests that the presence of children is a significant driver in higher rates of transport emissions (and changes in mobility preferences) (Clark et al., 2016). Büchs et al. (2013) write that household size has a larger effect on transport emissions than other household related energy emissions. They find that two

Table 4
Occupational differences in preferences for car ownership, electric mobility, and vehicle attributes.

a. Top panel: quantitative presentation of data									
	Other/Prefer not to answer	Unemployed/ Disability /Sick	Student	Retired	Nonprofit/ NGO	Academic institution	Government	Private sector	Chi-Square
Car Ownership									
No	38.4%	41.7%	43.7%	20.1%	19.1%	23.5%	17.6%	15.1%	S2 (7, n = 5059) = 343.81, $p < .001$
Yes	61.6%	58.3%	56.3%	79.9%	80.9%	76.5%	82.4%	84.9%	
<i>n</i>	310	415	765	676	251	540	511	1591	
Daily km travelled by car									
Not regularly	39.4%	47.5%	45.3%	29.8%	23.1%	30.5%	22.1%	18.5%	S2 (35, n = 5064) = 487.01, $p < .001$
< 20 km	26.1%	29.6%	29.8%	37.7%	33.1%	32.3%	28.7%	26.3%	
20–50 km	21.3%	18.6%	19.6%	23.9%	32.7%	21.1%	31.8%	32.0%	
50– 80 km	8.1%	3.4%	3.4%	4.4%	6.8%	10.0%	10.5%	11.3%	
80–100 km	2.3%	0.5%	0.9%	2.8%	2.8%	2.6%	2.5%	5.0%	
> 100 km	2.9%	0.5%	1.0%	1.3%	1.6%	3.5%	4.3%	6.8%	
<i>n</i>	310	415	766	677	251	541	512	1592	
EV driving experience									
Not sure	11.3%	6.3%	5.1%	2.2%	3.2%	2.6%	2.9%	1.9%	S2 (14, n = 5062) = 247.41, $p < .001$
No	75.8%	83.4%	76.5%	86.2%	74.1%	66.9%	69.5%	69.0%	
Yes	12.9%	10.4%	18.4%	11.5%	22.7%	30.5%	27.5%	29.1%	
<i>n</i>	310	415	766	676	251	541	512	1591	
EV Ownership									
No	96.8%	97.3%	96.0%	96.3%	85.7%	90.6%	88.5%	89.6%	S2 (14, n = 5064) = 108.79, $p < .001$
Yes, but sold	1.9%	1.0%	1.7%	1.5%	4.0%	3.9%	4.5%	2.8%	
Yes	1.3%	1.7%	2.3%	2.2%	10.4%	5.5%	7.0%	7.6%	
<i>n</i>	310	415	766	677	251	541	512	1592	
b. Bottom panel: narrative presentation of data									
Occupation ^a									
Car use^b									
Car Ownership	Car ownership is associated with employment, with 85.5% of those in the private sector owning a car versus less than 60% of those without employment. A similar association can be found for each of the countries, although in Denmark those in the private sector (81.7%) own a lower share to government (84.3%) and nonprofit (93%) employees, while in Norway retirees have the highest share of car ownership (90%) and in Iceland the lowest share of car ownership is by students (78.4%).								
KM per day	Daily car travel is associated with occupations with the private sector's higher share of car ownership linked to a lower share of those who rarely drive and a higher share of those who drive over 50 km a day (23.5% of the privately employed drive over 50 km a day versus for example 10.8% of those working for non-profits or NGOs).								
EV experience	EV driving experience is associated with employment, with 30.5% of academics having tried an EV versus 10.4% of the unemployed and 22.7% of those working in the nonprofit sector. This association returns for Denmark and Finland, but is invalid for the other countries.								
EV Ownership	EV ownership is similarly associated with employment, with 14.3% of those working for non-profit organizations or NGOs, 11.5% of government officials, 10.4% of private sector workers owning or having owned an EV, compared to between 2.7% and 4% of the not directly employed sample (students, unemployed, retired, “other”). After recoding to never owned an EV and currently or previously owned an EV, this association also recurs within the countries ($p = < .001$).								
EV Interest (non-EV owners)	For those not owning an EV, their interest is associated with occupation, with 75.5% of academics <i>somewhat or very interested</i> , versus 59% of the private sector, 51.7% of the unemployed and 47.4% of the pensioners and nonprofit sector. This extends to the countries ($p = < .002$) where those working in academic institutions also show more interest than the other sectors. The exception again is Iceland with its relative high percentages of interest across the sectors.								
Expected purchase price of next car	The expected expenditure is likewise associated with occupation with 26.6% of the private sector expecting to spend more than €30,000 versus about 22% for retirees, academics and government officials, 16.2% of nonprofit staff and 9.1% of unemployed. This extends to Denmark and Norway, and weakly to Finland and Sweden, but not for Iceland ($p = .047$). Interestingly, in Sweden only 4.4% of retirees expect to pay over €30,000 (versus 44.3% in Norway). More generally, academics and the private sector expect to pay the most, except in Iceland where it is the nonprofit sector.								
Car preferences^c									
Design and engineering: Speed/ acceleration, size/comfort, design/ style, ease of operation	Of these four questions, all show differences between occupations (KW, $p = < .002$). For <i>speed/acceleration</i> , <i>size and comfort</i> , and <i>design and style</i> the mean rank is lowest for retirees and highest for the private sector. The mean rank for <i>ease of operation</i> is lowest for the other category and highest for the nonprofit sector.								
Costs and Impacts: Technical reliability, safety, fuel economy/financial savings, price, environmental impact	Occupation shows that <i>safety</i> is a shared concern (KW, $p = .055$) but that differences exist for <i>technical reliability</i> , <i>fuel economy</i> , <i>purchase price</i> , and <i>environmental impact</i> . Regarding <i>technical reliability</i> , academics and then the private sector and pensioners rank this highly, while the nonprofit sector scores this remarkably low. <i>Fuel economy</i> is highest ranked by students, and lowest by the private sector, the nonprofit sector and the other category. Especially the unemployed have a high mean rank for <i>price</i> , while the private sector, nonprofit, government, and academics share a similar mean rank (although academics score a median lower). The mean rank of <i>environmental impact</i> is highest for academics, followed by students, government officials and nonprofits. It is lowest for pensioners and the other category.								
EV preferences: Range, Battery life, Public Charging, Charging time, V2G	There is no variance between occupation and the importance of <i>V2G capacity</i> , implying a shared level of concern across sectors. The other questions show variance. The mean rank of <i>EV Range</i> is highest for the private sector and lowest for the nonprofit and other category. For <i>battery life</i> , retirees have the highest mean rank while the nonprofit sector scores this lowest (after the other category). The importance of <i>public charging</i> is highest for students, surprisingly, followed by the private sector and academics. It's lowest for the nonprofit sector (also after the other category). The mean rank for <i>charging time</i> is highest for the private sector but closely followed by government officials and retirees. The lowest mean rank is for the unemployed and academics (after the other category).								

Notes: ^aAll tests $p < 0.001$, unless where indicated, ^bBased on Pearson Chi-Square test, ^cBased on Independent Sample Kruskal-Wallis test.

Table 5
Age differences in preferences for car ownership, electric mobility, and vehicle attributes.

a. Top panel: quantitative presentation of data							
	< 25	25–34	35–44	45–54	55–64	65 >	Chi-Square
Car Ownership							
No	42.1%	30.7%	21.5%	17.8%	19.4%	11.7%	S2 (5, n = 5056) = 248.93, $p < .001$
Yes	57.9%	69.3%	78.5%	82.2%	80.6%	88.3%	
<i>n</i>	897	1034	964	944	728	489	
Daily km travelled by car							
Not regularly	41.9%	34.7%	27.0%	23.1%	24.3%	21.8%	S2 (25, n = 5061) = 199.05, $p < .001$
< 20 km	30.1%	27.0%	30.9%	27.2%	30.0%	38.4%	
20–50 km	20.2%	24.3%	26.7%	30.1%	29.1%	28.0%	
50–80 km	5.5%	8.3%	8.1%	10.2%	7.3%	7.8%	
80–100 km	1.4%	3.4%	3.0%	3.9%	4.0%	1.2%	
> 100 km	1.0%	2.4%	4.4%	5.6%	5.3%	2.9%	
<i>n</i>	898	1035	964	945	729	490	
EV driving experience							
Not sure	7.9%	3.2%	2.8%	2.1%	2.6%	2.2%	S2 (10, n = 5059) = 111.90, $p < .001$
No	68.8%	69.5%	74.4%	74.6%	79.7%	84.3%	
Yes	23.3%	27.3%	22.8%	23.3%	17.7%	13.5%	
<i>n</i>	898	1035	964	945	728	489	
EV Ownership							
No	91.4%	90.5%	90.2%	92.6%	95.7%	96.3%	S2 (10, n = 5061) = 45.24, $p < .001$
Yes, but sold	4.1%	3.3%	3.0%	2.2%	0.8%	1.0%	
Yes	4.5%	6.2%	6.7%	5.2%	3.4%	2.7%	
<i>n</i>	898	1035	964	945	729	490	

b. Bottom panel: narrative presentation of data	
	Age ^a
Car use^b	
Car Ownership	Car ownership is associated with age ($r_s = .208$) more or less increasing with higher age groups and peaking at 45–54 (82.2%) and for the over 65-age group (88.3%). A similar association and upward trend can be found for each of the countries, with the exception of Iceland where the trend is parabolic as 100% of the 45–54 group owns a car.
KM per day	Daily car travel is similarly associated with age ($r_s = .143$). However, where before we observed that with an increase in car ownership comes a lower share of those who hardly drive at all and a higher share of those who drive over 50 km a day, for age this is slightly different as larger car ownership coincides with a lowering of the percentage of those who only drive rarely, but most km a day are driven by the 45–54 age group (5.6%). Those over 65 have the lowest share of persons only rarely driving every day (21.8%) while this is highest for those under 25 (41.9%). Age is also associated with driving patterns across all five countries.
EV experience	EV driving experience is associated and very weakly correlated to age ($r_s = -.040$), with 25–34 year olds having the highest share of experience (27.3%) and the age group over 65 (13.5%) having the lowest. This association returns within the countries ($p < .002$), except for Iceland. In Finland the 45-54 group has the highest share of experience, while in Iceland the 55-64 cohort does.
EV Ownership	EV ownership is associated and weakly correlated to age ($r_s = -.065$), but not equally distributed across the cohorts. Instead the cohorts of 25–34 (6.2%) and 35–44 (6.7%) show the highest shares of EV ownership, while it is lowest for those over 65 (2.7%) Those under 25 score 4.5%. After recoding to never owned an EV and currently or previously owned an EV, this association returns within Denmark ($p = .001$) and Sweden ($p = .002$), but not in the other countries (although Norway: $p = .03$).
EV Interest (non-EV owners)	For those not owning an EV, their interest in electric vehicles is associated with age ($r_s = -.112$), with 66.6% of the 25–34 <i>somewhat or very interested</i> , versus 50% of the 54–65 cohort. This extends to Denmark ($p = .001$) and Norway, but Sweden could be included ($p = .018$). In Denmark interest is high among 25–34 year olds (68.1%) but low for 45–54 year olds (45.6%). Norway shows similar percentages for these cohorts, while in Sweden it levels off.
Expected purchase price of next car	The expected costs of a new car are associated and correlated to age ($r_s = .123$), with 30.2% of the under 25 group imagining to pay less than €10,000, while those over 65 show the highest share of people willing to pay more than €30,000. This association returns within Finland, Norway and Sweden, but cannot be confirmed for Iceland and is not present for Denmark. Interestingly, where in most countries the 45-54 and > 65 cohorts have the highest share of people expecting to pay over €30,000, in Sweden it is the 35-44 cohort (28.9%).
Car preferences^c	
Design and engineering: Speed/acceleration, size/comfort, design/style, ease of operation	Of these four questions, all show differences between age cohorts ($p < .005$). For <i>speed/acceleration</i> this is most obvious with a drop in the mean rank and median for those over 65. For <i>size and comfort</i> , we see an increase in mean rank until the cohort 35–44, after which it decreases again. <i>Design and style</i> is most popular among those under 25 and then slowly drops. The mean rank for <i>ease of operation</i> peaks for those in the 45–54 cohort.
Costs and Impacts: Technical reliability, safety, fuel economy/financial savings, price, environmental impact	Age shows that <i>safety</i> is a shared concern, as is the distribution of <i>fuel economy and financial savings</i> , although the later sees a drop in median for those over 65 years old. For <i>technical reliability</i> , <i>purchase price</i> ($p = .045$), and <i>environmental impact</i> ($p = .002$) there are differences across age groups. Regarding <i>technical reliability</i> , our sample shows a large increase in mean rank and median (and thus importance) from those under 34 and over 35. Regarding <i>price</i> , although those over 65 have a lower mean rank and median, there are no significant pairwise relationships (with Bonferroni correction). The mean rank of <i>environmental impact</i> is highest for those in the cohort of 25–34 and lowers (slightly) with age.
EV preferences: Range, Battery life, Public Charging, Charging time, V2G	Age shows variance on each of the questions. The mean rank of <i>EV Range</i> is surprisingly low for those under 25 and peaks with those aged 45–54. For <i>battery life</i> , we can observe an increasingly higher mean rank peaking for those over 65, although the cohorts 25–34 and 35–44 have almost identical mean ranks. The importance of <i>public charging</i> ($p = .038$) is highest for the 25–34 cohort, then drops and increases again for those 45–54 with another peak at 55–64 (however, no pairwise significant relationships). The mean rank for <i>charging time</i> rises until the 45–54 cohort and then slowly lowers again (with lower medians for the two youngest cohorts). Age is also one of the few variables where we witness variance for <i>V2G capacity</i> , with the groups 25–34 and 35–44 scoring this lower than those under 25 after which it rises again to peak for those aged 54–65.

Notes: ^aAll tests $p < 0.001$, unless where indicated, ^bBased on Pearson Chi-Square test, ^cBased on Independent Sample Kruskal-Wallis test.

Table 6
Household differences in preferences for car ownership, electric mobility, and vehicle attributes.

a. Top panel: quantitative presentation of data						
	1	2	3	4	5 +	Chi-Square
Car Ownership						
No	39.8%	21.9%	18.9%	14.4%	15.7%	S2 (4, n = 4940) = 246.89, $p < .001$
Yes	60.2%	78.1%	81.1%	85.6%	84.3%	
<i>n</i>	1381	1690	762	700	407	
Daily km travelled by car						
Not regularly	42.7%	28.5%	24.5%	19.0%	16.0%	S2 (20, n = 4945) = 235.78, $p < .001$
< 20 km	26.5%	32.1%	29.5%	33.4%	27.0%	
20–50 km	19.7%	25.8%	30.3%	30.2%	36.1%	
50–80 km	6.4%	6.6%	9.2%	9.8%	11.8%	
80–100 km	1.9%	3.0%	2.9%	3.4%	4.9%	
> 100 km	2.8%	4.0%	3.7%	4.1%	4.2%	
<i>n</i>	1381	1693	763	701	407	
EV driving experience						
Not sure	4.4%	3.3%	3.7%	3.6%	2.0%	S2 (8, n = 4943) = 120.82, $p < .001$
No	80.9%	76.6%	68.9%	65.9%	64.9%	
Yes	14.7%	20.2%	27.4%	30.5%	33.2%	
<i>n</i>	1380	1692	763	701	407	
EV Ownership						
No	96.6%	94.3%	90.0%	88.7%	82.6%	S2 (8, n = 4945) = 122.95, $p < .001$
Yes, but sold	1.3%	2.1%	3.4%	3.3%	5.7%	
Yes	2.1%	3.6%	6.6%	8.0%	11.8%	
<i>n</i>	1381	1693	763	701	407	
Cars per household						
0	41.3%	17.0%	9.2%	6.0%	4.2%	S2 (20, n = 4945) = 1134.33, $p < .001$
1	50.8%	55.0%	47.1%	42.6%	30.2%	
2	6.0%	23.2%	31.4%	40.7%	44.2%	
3	1.2%	3.4%	9.8%	7.7%	12.3%	
4	0.4%	0.8%	1.0%	2.0%	4.7%	
5 >	0.3%	0.7%	1.4%	1.0%	4.4%	
<i>n</i>	1379	1692	762	700	407	
b. Bottom panel: narrative presentation of data						
Household size ^a						
Car use^b						
Car Ownership	Car ownership is associated with household size, with the number of cars positively correlated with larger households ($r = .158$). A similar association can be found for each of the countries with strong correlations for Denmark ($r = .432$), Iceland ($r = .422$) and Norway ($r = .302$), but less so in Sweden ($r = .089$) and Finland ($r = .079$).					
Km per day	Daily car travel is similarly associated with household size with larger households correlating to more km a day ($r_s = .193$). The association extends to Denmark, Finland and Sweden, but is less clear for Norway ($p = .006$) and absent for Iceland ($p = .134$), although it is possible to find a positive correlation in each of the countries ($p < .001$) with Denmark ($r_s = .177$), Finland ($r_s = .228$), Iceland ($r_s = .116$ with $p = .002$), Norway ($r_s = .144$), Sweden ($r_s = .182$).					
EV experience	EV driving experience is associated with household size, with larger households having a larger percentage that have tried an EV. This association returns within the countries ($p = < .002$), except for Iceland ($p = .345$).					
EV ownership	EV ownership is similarly associated with household size. After recoding to never owned an EV and currently or previously owned an EV, this association returns for all countries except Iceland ($p = .011$). For instance, 19% of the more than 5 person households in Norway claim to own an EV, compared to 5.2% of the two person households in Norway. These percentages are lowest in Denmark where 5.7% of the 5+ households claim to own an EV versus 2.8% of the 2 person households (in Finland 6.5% and 2.6% respectively).					
EV interest (non-EV owners)	Households and EV interest are associated, which becomes even clearer after recoding with 67.3% of the 5+ households <i>somewhat</i> or <i>very interested</i> against 50.9% of the single households ($r_s = .126$).					
Expected purchase price of next car	The expected costs of a new car are also associated with household size, with 27.6% and 28.4% of the 4 and 5+ person households respectively expecting to pay more than €30,000 for their next car compared to 14% of the one person households. This association returns within Denmark ($p = .001$ and $r_s = .132$), Finland ($p < .001$ and $r_s = .166$), and Sweden ($p < .001$ and $r_s = .253$) but is less present for Iceland ($p = .032$ and $r_s = .143$) and Norway ($p = .065$ and $r_s = .075$). That said, the frequencies highlight that Denmark, Finland and Norway show two peaks in the percentage that is willing to spend over €30,000, one for 2 person households and one for 4 or 5+ person households. This is not the case for Iceland (upward trend) and Sweden (where 2 person households equal one-person households in the percentage expecting to pay over €30,000).					
Car Preferences^c						
Design and engineering: Speed/acceleration, size/comfort, design/style, ease of operation	Of these four questions, only <i>ease of operation</i> shows no variance among household sizes (KW, $p = .419$). For <i>speed/acceleration</i> the variance is most obvious with an increase of mean rank per household size. For <i>size and comfort</i> we see a similar increase in mean rank and a jump in median for the 5+ category. <i>Design and style</i> also increases with household size.					
Costs and Impacts: Technical reliability, safety, fuel economy/financial savings, price, environmental impact	Household size stands out in that <i>safety</i> is not a shared concern as 3 and 4 person households score this higher than single person households. A similar variance between single and more than 2 person households is visible for <i>environmental impact</i> . The other three are not ranked differently across household sizes, although <i>technical reliability</i> sees a drop in median for 3 person households.					

(continued on next page)

Table 6 (continued)

b. Bottom panel: narrative presentation of data	
	Household size ^a
EV preferences: Range, Battery life, Public Charging, Charging time, V2G	Households vary on the first three questions, but not the last two. The mean rank of <i>EV Range</i> ($p < .005$) is lowest for single person households and varies mostly from 3 and 4 person households. In turn the mean rank for <i>battery life</i> ($p = .047$) is lowest for 5+ households and differs most from 2 person households. <i>Public charging</i> ($p < .001$) is highest for single and 2 person households and varies mostly from 5+ sized households. Lastly, the mean ranks for <i>charging time</i> and <i>V2G capacity</i> do not vary across household sizes, although <i>charging time</i> sees a drop in median and rank for 5+ households, in line with what we observe for public charging.

Notes: ^aAll tests $p < 0.001$, unless where indicated, ^bBased on Pearson Chi-Square test, ^cBased on Independent Sample Kruskal-Wallis test.

adult households have almost three times higher transport carbon emissions than single adult households, and also that two adult households with one child have a “significantly higher total” (Büchs et al., 2013; 119). In Sweden, families tend to dislike electric vehicles and prefer large, conventional cars given that they symbolize welfare and status and can also haul larger amounts of equipment. Consumer research has shown that Swedish drivers do not consider an electric vehicle to be “a real car” and that “electric vehicles cannot have a towing hook – a real barrier in Sweden!” (Nykvist and Nilsson, 2015: 40).

7.2. Nordic findings

Household size, analyzed by combining the number of adults and children in a household and subsequently placing in categories, also influences car and electric vehicle use and preferences. Our sample shows how car ownership increases with household size from 60.2% for single households to 85.6% of 4 person households. Similarly, daily travel increases as 20.9% of those in a 5+ household drive over 50 km a day versus 13.6% of 2 person households. In contrast to some of the earlier variables, household size extends this upward trend to EV experience and EV ownership; the larger the family the larger the share that has tried (33.2% of 5+ households versus 20.2% of 2 person households) or owns an EV (11.8% of 5+ households versus 2.1% or 3.6% of single and two person households). This results with higher levels of multicar households (the mean car ownership per household size increases from 0.77 to 2.03) and a clear jump between single households and two person households for the percentage that does not own a car at all (41.3% of single households to 17.0% of two person households).

As Table 6 reveals, household size has clear links to car ownership, daily km and EV ownership, experience and interest within our survey sample. However, its relationship to car and EV preferences is less clear, although the attached importance seems to increase group wise for larger households. In general, larger households seem to have more cars, are willing to pay more for them, have more experience with EVs and a larger share that owns them, while those not owning are more interested in EVs. At the same time, larger households seem to demand more from their cars, in terms of engineering, impacts and consequences and regarding their preferences for electric vehicles and EV infrastructure. Moreover, households seem to vary less in their preferences across countries, but also especially within the countries. When they do, it's primarily on the engineering and design of the car, although counterintuitively, the importance of speed and design increases just as much as the importance of size – while we would expect speed and design to be something primarily for smaller households.

8. Implications for policy, environmental change, and sustainability transitions

Although our study was intended to make an empirical contribution more than a theoretical or conceptual one, it still contributes to ongoing discussions about policy, change, and transitions in five meaningful ways.

First, it offers insight into the specific regional context of the Nordic energy transition (or more relevantly its ongoing transition to electric mobility). The Nordic region offers a useful testbed for examining the desirability as well as social (and political) dimensions to the decarbonization of transport, with some even calling it a model or litmus test for the rest of the world (Sovacool, 2017, 2013). Less controversially, the Nordic region has an undeniable lead market potential compared to its other neighbors in exploiting electric vehicle technology. As Table 7 indicates, Norway leads all of Europe in its market share (17.1%) and growth of EV adoption over the past few years (more than 500% from 2012 to 2015); Sweden is also a European market leader (Berkeley et al., 2017). Our survey respondents live in a real-world environment undergoing decarbonization. Our results therefore have topical or geographic relevance for indicating how the ongoing Nordic transition to electric mobility is being perceived by different groups of actors, especially how demographic attributes can shape knowledge, patterns, and preferences across Nordic countries. Put another way, there is no uniform set of preferences—we see considerable variation cross demographic attributes in our sample.

Second, our results offer a unique contribution to industry and business strategy. Business strategies are often described in terms of stimulating regulations or changing standards, or the conflicting priorities of incumbents and new entrants (Wesseling et al., 2015). Our novelty in this dimension is pointing instead towards more effective communication and marketing campaigns. Our analysis suggests the emergence of distinct market segments that may be useful for automotive manufacturers, dealerships, and others trying to push EVs. While it is fairly easy to summarize our findings by pointing to the demographic factors that have the strongest influence on preferences for EVs in the Nordic countries—men, aged 25–45 years old, from large households, highly educated and employed (in academia or civil society)—two other groups could be potential EV markets: highly educated women and young retirees. These two groups are both characterized by high car ownership and high income/expenditure levels. They seem to hold preferences that demand less than adult men from their cars in terms of acceleration or range, and they drive relatively shorter distances, which both fit the functionality requirements of modern EVs. And that is before one accounts for the greater environmental and fuel efficiency awareness of women. Yet, at the same time, women and retirees are also showing less interest and experience with EVs. This contrasts with the men in our sample, who have more than twice the likelihood of owning or experiencing an EV but are also less interested in the purported benefits of electric mobility. This indicates that for men the inherent benefits of an EV are not its core selling point, and that women are not reached by current EV support policies. A more targeted information/promotion campaign might help overcome these obstacles.

Third, for electricity policy and in particular vehicle-to-grid policy mechanisms (Kester et al., 2018), our results inform ongoing efforts to decarbonize electricity by showing the classes of users most likely (or not) to try to couple electricity and transport systems together via V2G. While general interest in V2G is low across our sample, and we do not find any relationships between V2G interest and occupation, education or household size, there is slightly more interest from men than women,

Table 7

Sales of Battery Electric Vehicles in Europe, 2012–2015.

Source: [Berkeley et al., 2017](#)

Country	2012	2013	2014	2015	2015 Market share (%)	% Growth 2012–15	% Growth 2014–15
Norway	3950	7882	18,090	25,814	17.10	553.5	42.7
France	5663	8779	10,610	17,268	0.90	204.9	62.8
Germany	3784	6441	9629	13,605	0.42	259.5	41.3
UK	2150	3584	6697	9934	0.38	362.0	48.3
Denmark	537	564	1620	4381	2.11	715.8	170.4
Switzerland	785	1189	1780	3882	1.20	394.5	118.1
Netherlands	3850	5582	3403	3859	0.86	0.2	13.4
Sweden	947	1545	1392	3253	0.94	243.5	133.7
Austria	427	654	1281	1677	0.54	292.7	30.9
Belgium	826	574	1358	1621	0.32	96.2	19.4
Spain	399	629	990	1461	0.14	266.2	47.6
Italy	520	870	1101	1460	0.09	180.8	32.6
Western Europe	24,150	38,624	58,582	89,640	0.68	271.2	53.0
Market share (%)	0.21	0.34	0.49	0.68			

although counter intuitively the age groups most invested in EVs (25–45) are the ones showing slightly less interest in V2G. In simpler terms: V2G is not perceived (or understood) as the same as EVs, which leads to less interest for this newly developing technology. The fact that V2G preferences do not significantly change across any of the demographic categories implies that there is an overall lack of consumer knowledge about the product, making it difficult to properly design policies for V2G implementation.

Fourth, our results can inform approaches attempting to model or predict energy consumption profiles, diffusion patterns, or psychological processes. In developing their own model of sustainability orientated values, [Axsen and Kurani \(2013\)](#) did not look at demographic conceptualizations of identity (such as gender or nationality), but acknowledge their potential importance in influencing preferences. In particular, our data lends itself to better calibrated energy or integrated assessment models such as enhancing “behavioral realism” ([McCullum et al., 2017](#); [Wolinetz et al., 2018](#)) or better reflecting “social influence” ([Pettifor et al., 2017](#)); more attenuated psychological models such as Protection Motivation Theory or those seeking to predict pro-environmental action ([Bockarjova and Steg, 2014](#)); and/or enhanced adoption and diffusion models ([Geels and Johnson, 2018](#)). Our results show how

grander, broader technology curves can break into more discrete, heterogeneous classes of users and adopters. [Bockarjova and Steg \(2014\)](#) even argue that individual considerations seem to be a stronger motivation for “close” adoption indicators (such as the overall evaluation of EVs or intentions to purchase) than “distant” indicators (such as collective considerations about energy security, the environment or social welfare). Our findings suggest that we must unpack the “individual” to be more than just an automaton who rationally calculates cost or efficacy in these (and other) models. For, if true that consumer choice and behavior are shaped by cultural and symbolic motives ([Noppers et al., 2014](#); [Abrahamse and Steg, 2009](#)), then a more refined assessment of demographic criteria can condition the extent that such symbols resonate with the cognitions and identities of particular types of people.

Fifth, and lastly, our results deepen ongoing discussions and perspectives within the field of sustainability transitions ([Loorbach et al., 2017](#); [Cherp et al., 2018](#); [European Environment Agency, 2018](#)). Within that literature, although values and culture are seen as operating across multiple scales (such as niches and regimes) ([Schot and Geels, 2008](#); [Roberts and Geels, 2018](#)), demographics are often envisioned as forming part of the landscape, making them latent and slow-changing elements of the sociotechnical system (along with political ideologies or

Table 8

Correlations between demographics, car experience and preferences.

Source: Authors.

	Gender ^a	Education ^b	Age	Household Size
Car Ownership	-.118**	.116**	.209**	.206**
Km per day	-.188**	.097**	.142**	.190**
EV Experience	-.157**	.133**	-.039**	.142**
EV Ownership	-.070**	.061**	-.072**	.128**
Interest in EV	-.053**	.132**	-.117**	.129**
Importance of Speed and Acceleration	-.056**	.009	-.100**	.102**
Importance of Size and Comfort	.001	.035*	-.041**	.141**
Importance of Design and Style	-.054**	-.001	-.139**	.079**
Importance of Ease of Operation	.074**	.074**	.041**	.008
Importance of Technical Reliability	-.087**	.134**	.129**	.002
Importance of Safety	.133**	.030*	.034*	.057**
Importance of Fuel Economy and Financial Savings	.085**	.016	-.019	.015
Importance of Price	.096**	-.028*	-.003	-.011
Importance of Environmental Impact	.107**	.098**	-.039**	.060**
Importance of EV Range	-.135**	.070**	.095**	.043**
Importance of EV Battery Life	-.016	.021	.105**	-.002
Importance of EV Public Chargers	.041**	.026	.024	-.035*
Importance of EV Charging Time	.001	.039**	.067**	.015
Importance of EV V2G Capability	.062**	-.006	.037**	.019
Importance of General Environment	.97**	.086**	-.107**	.071**

Notes: ** Correlation is significant at the 0.01 level * Correlation is significant at the 0.05 level. ^a 1 = M, 2 = F, 3 = Other. ^b 1 = Other, 4 = Postgrad.

macroeconomic trends) (Van Driel and Schot, 2005). Or, social norms, values, and culture are seen as hindering innovation or contributing to soft institutional failures (Weber and Rohracher, 2012). Instead, our study shows how demographic attributes can be predetermining factors that influence behavioral antecedents or preferences for sustainable forms of mobility. Wider social categories or experiences—the birth of a child, transient unemployment, an increase in income, the onslaught of a chronic disease as one ages—may have just as much salience as innovation patterns or availability of infrastructure in explaining transition preferences and individual adoption patterns. Moreover, within the transitions literature, power and politics are often envisioned as a deliberative struggle over democracy (Geels et al., 2018; Hess, 2018), or a battle at the level of social movements or political parties fighting for grassroots innovation and change (Seyfang and Smith, 2007; Avelino et al., 2018; Lockwood, 2018; Gernert et al., 2018). In contrast, our study shows how preferences and adoption patterns can also be mediated and influenced by identity politics that come to define a sense of personal self, leading to different publics. An implication here is that processes affecting sociotechnical and environmental change manifest themselves not only on national and global scales, but at more micro individual, interpersonal, and discrete levels.

9. Conclusion

To conclude, the influence of demographics on decarbonizing transport—reflected in preferences for conventional forms of mobility as well as electric vehicles and V2G—is important and complex. As Table 8 summarizes, we see an influence between gender and car ownership, kilometers driven, and experience with and ownership of electric vehicles, all orientated towards men, as well as education (associated with similar attributes). Occupation and employment also influence stated preferences: car ownership is associated with employment as well as occupation, with those working for non-profit organizations most likely to own electric vehicles and academics at universities most associated with interest in owning an electric vehicle – to us indicating the importance of willingness to pay extra (non-governmental organizations) and the availability of information (academics). The influence of age is more distinct, with ownership of electric vehicles concentrated among the younger middle aged (those 25–44 years of age) and high preferences for the safety and cost savings attributes of vehicles. Interestingly, and contrary to some of the literature, Fig. 2 indicates that larger families also say they prefer to own electric vehicles, and household size correlates to car ownership and

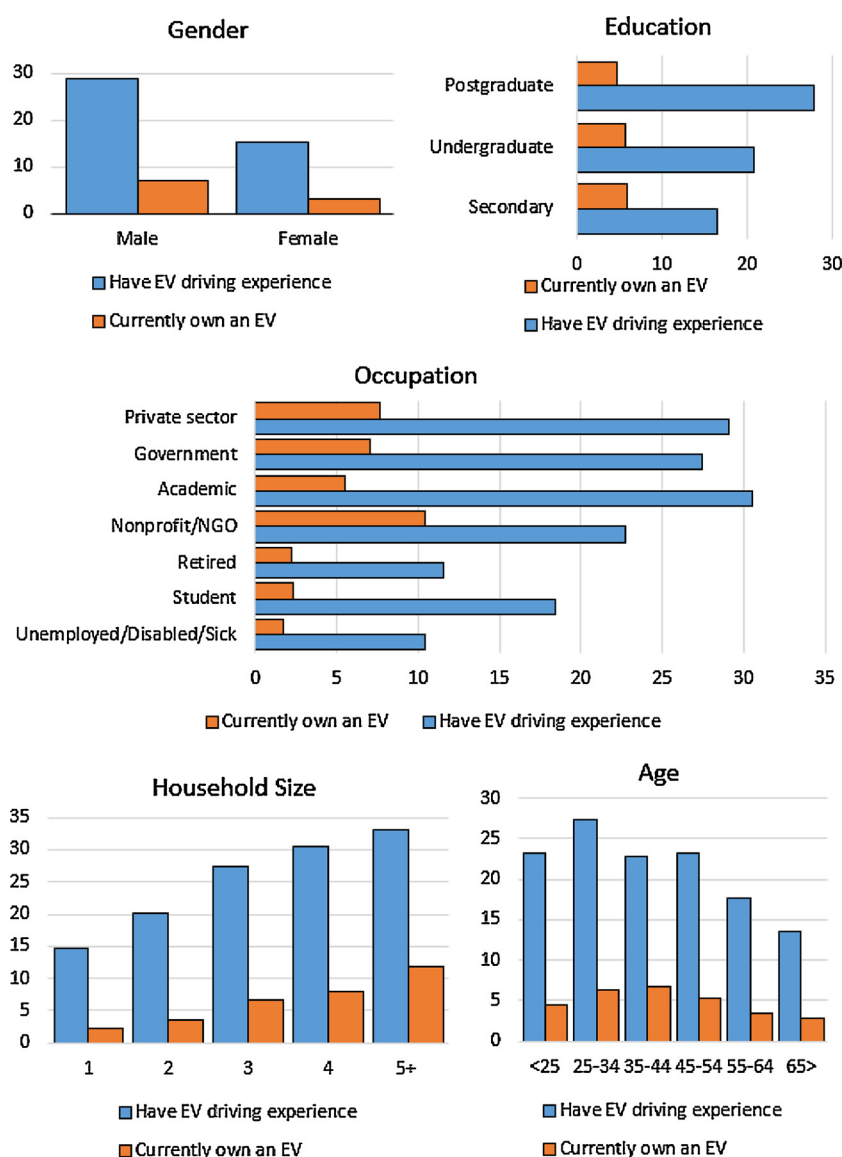


Fig. 2. Summary of Demographic Patterns for Electric Vehicle Driving Experience and Ownership in the Nordic Region.

greater daily travel needs. It demonstrates as well that unemployment, illness, or disability strongly (and negatively) impact EV experience and ownership patterns. Moreover, our analysis reveals other market segments where electric vehicles may take root, e.g. among higher income females and retirees/pensioners. It lastly confirms that preferences for V2G vary little across demographic attributes given perhaps lack of experience or knowledge with the relatively novel nature of that technology.

With this in mind, we offer two broader conclusions. First, in terms of energy and transport transitions, our findings suggest that the decisions made about mobility, electric vehicles, and V2G are not always purposively rational. Current discussions and deliberations about electric mobility are seamlessly intertwined with, or at least influenced by, identity politics. The decisions made about transport can therefore transcend purely economic self-interest, logic, and rationality and involve elements as diffuse as performative gender roles, education and training, conceptions of the family, training and occupation, and the temporality of both age and experience. Demographics, simply put, shape mobility patterns, access to mobility, existing preferences and future purchasing intentions for new innovations such as EVs (and, perhaps as it becomes more established, V2G). These demographics ultimately influence the desirability and acceptability of sociotechnical pathways.

Second, the heterogeneity and variety across demographic groups (and diversity of different market segments or publics) somewhat strongly suggests that “blunt” policy instruments, intended to work across universal audiences, will be less effective than those that are more targeted at distinct subpopulations. Our results suggest that conventional (and electric) passenger vehicles satisfy complicated (and constantly evolving) preferences that cut across multiple dimensions. Electric vehicles can not only provide mobility services, they can also reinforce gender roles, signify levels of education and occupation, symbolize luxury or class, and reflect various elements of lifestyle and family domestication. Demographics may be symbiotic, parasitic, or non-relational to any particular innovation or decarbonization pathway. This complexity demands we focus not only on more macro orientated transitions processes such as niches, regimes, or systems, but also transitions at more micro and personal scales. User preferences, values, knowledge, and experience may be just as important as design of technology or the state of infrastructure in why people may embrace, or reject, attempts at decarbonizing transport.

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